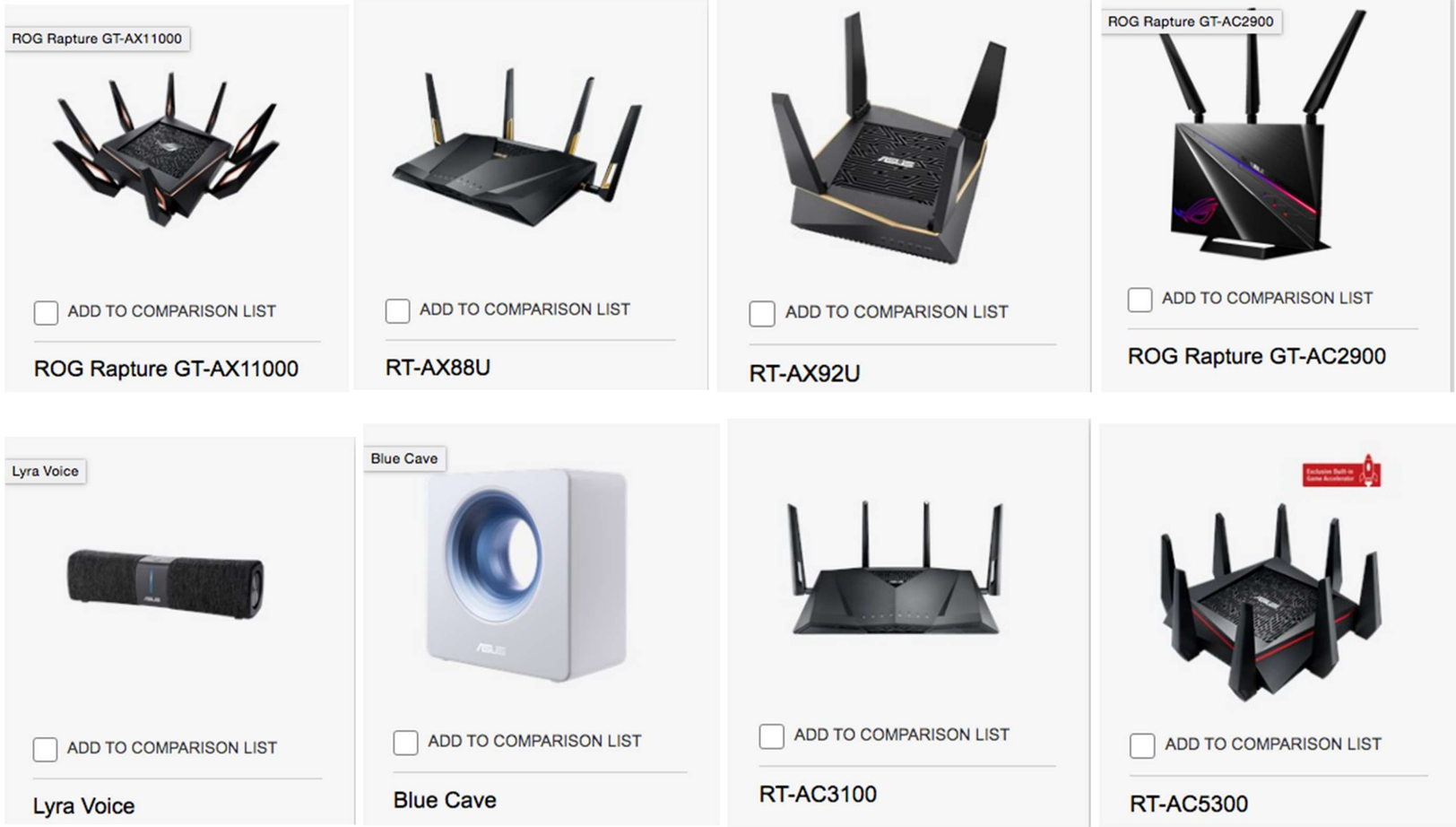
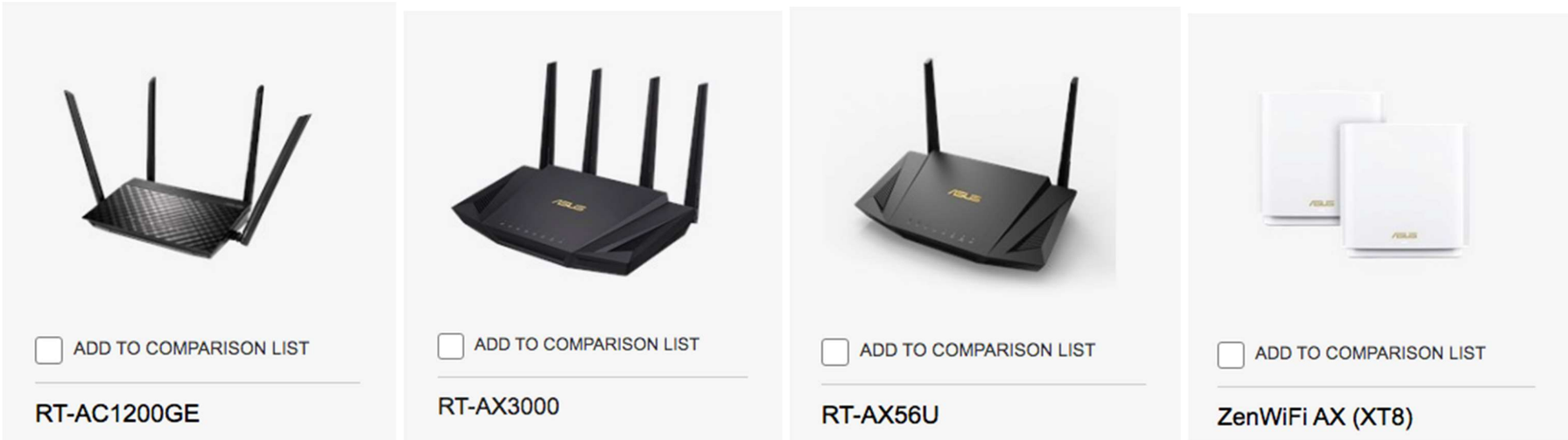
Exhibit 4

➢ **The combination of the below Asus Wi-Fi routers and Asus Wi-Fi enabled laptops infringe the asserted claims**



https://www.asus.com/Networking/Wireless-Routers-Products/



https://www.asus.com/Networking/Wireless-Routers-Products/

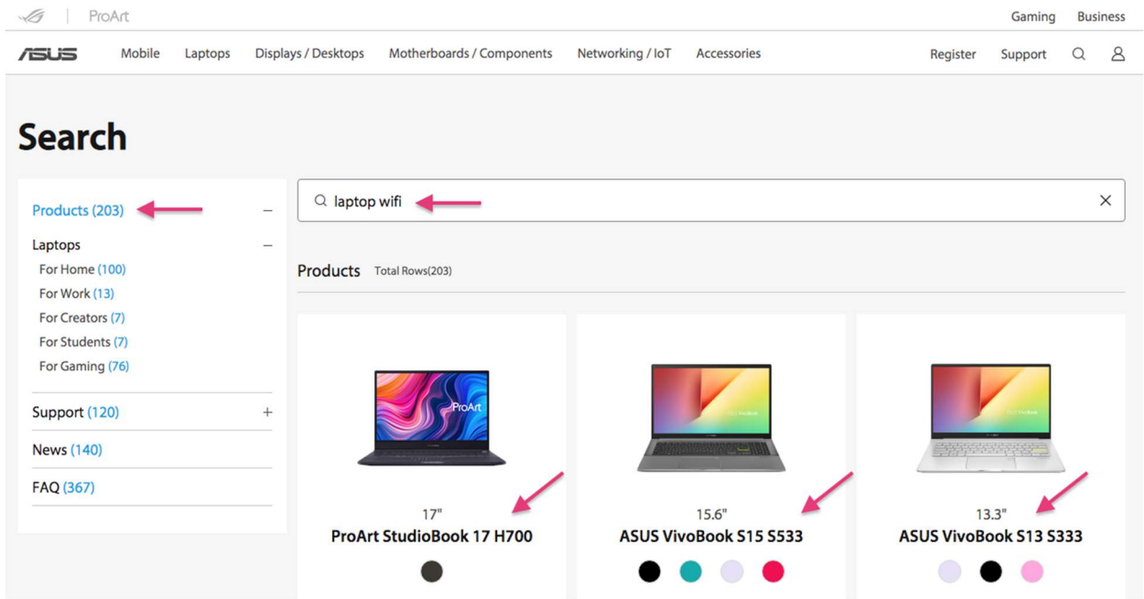
Accused Products: combinations of Asus routers (see Accused Routers list below) and Asus laptops (see Accused Laptops list below)

Product Model List: GT-AX11000, RT-AX88U, RT-AX92U, GT-AC2900, Lyra Voice, Blue Cave, RT-AC87U, RTAC58U, RT-AC3100, RT-AC5300, RT-AC85P, RT-ACRH17, RT-AC1300G PLUS, RT-AC1300 UHP, RT-AC59U, BRT-AC828, RT-AC65P, RT-AC2400, RT-AC1750 B1, RT-AC1750U, RT-AC57U V2, RT-AC58U V2, RT-AC85U, RT-AC1300G PLUS V2, ROG Rapture GT-AC5300, RT-AC1500UHPRT-AC88U, RT-ACRH12, RT-AC1200GE, RT-AC1500G PLUS, RT-AC1300G PLUS V3, RT-AC57U V3, RT-AC58U V3, RT-AC59U V2, RT-AX89X, RT-AX1800, RT-AX3000, RT-AX56U, RT-AX58U, RT-AX82U, RT-AX86U, TUF Gaming AX3000, ZenWiFi AX (XT8), ZenWiFi AC (CT8), ZenWiFi AX Mini (XD4)

- **Asus makes and sells over 200 models of laptops that support Wi-Fi standards such as 802.11ac. These laptops meet the requirements of end units recited in the claims and such as communications end units described in the patent specification, for example computers**.

Evidence:

{15}



{16}

Some example models are:

[ProArt StudioBook 17 H700]

[ASUS VivoBook S15 S533]

[ASUS VivoBook S13 S333]

[ASUS ZenBook 15 UX534]

ASUS ExpertBook B9 B9450

ASUS Chromebook Flip C436

ProArt StudioBook 15 H500

ProArt StudioBook Pro 15 W500

ZenBook Duo UX481

ProArt StudioBook Pro X W730

ProArt StudioBook Pro 17 W700

ASUS VivoBook S15 S532

ASUS M415 (AMD Ryzen 5000 Series)

ASUS M515 (AMD Ryzen 5000 Series)

ASUS L410

ASUS L210

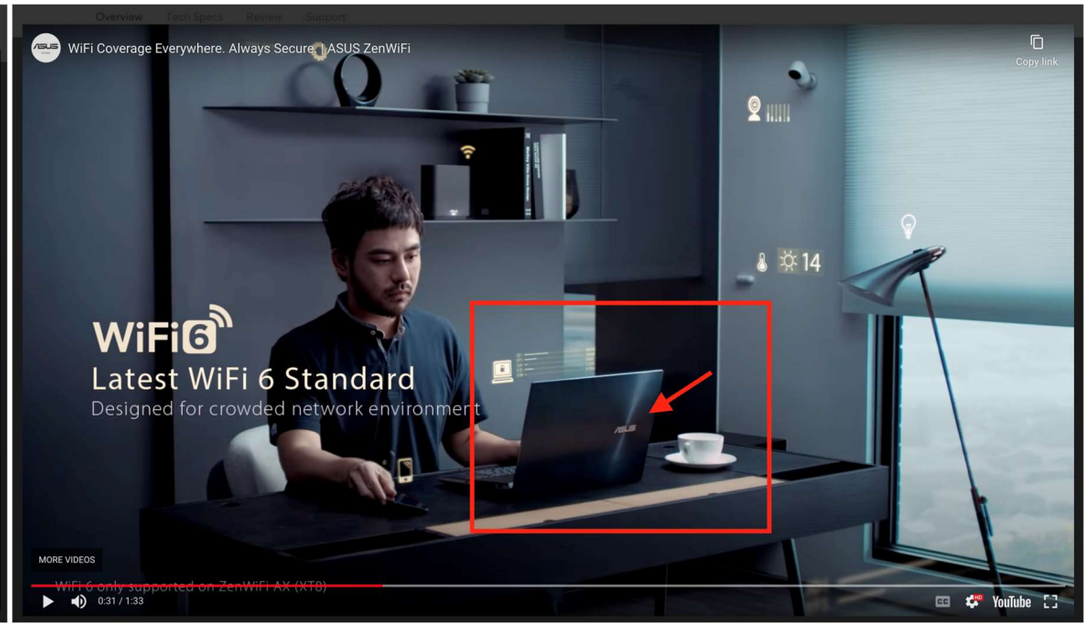
ASUS L510

R543

ASUS BR1100C

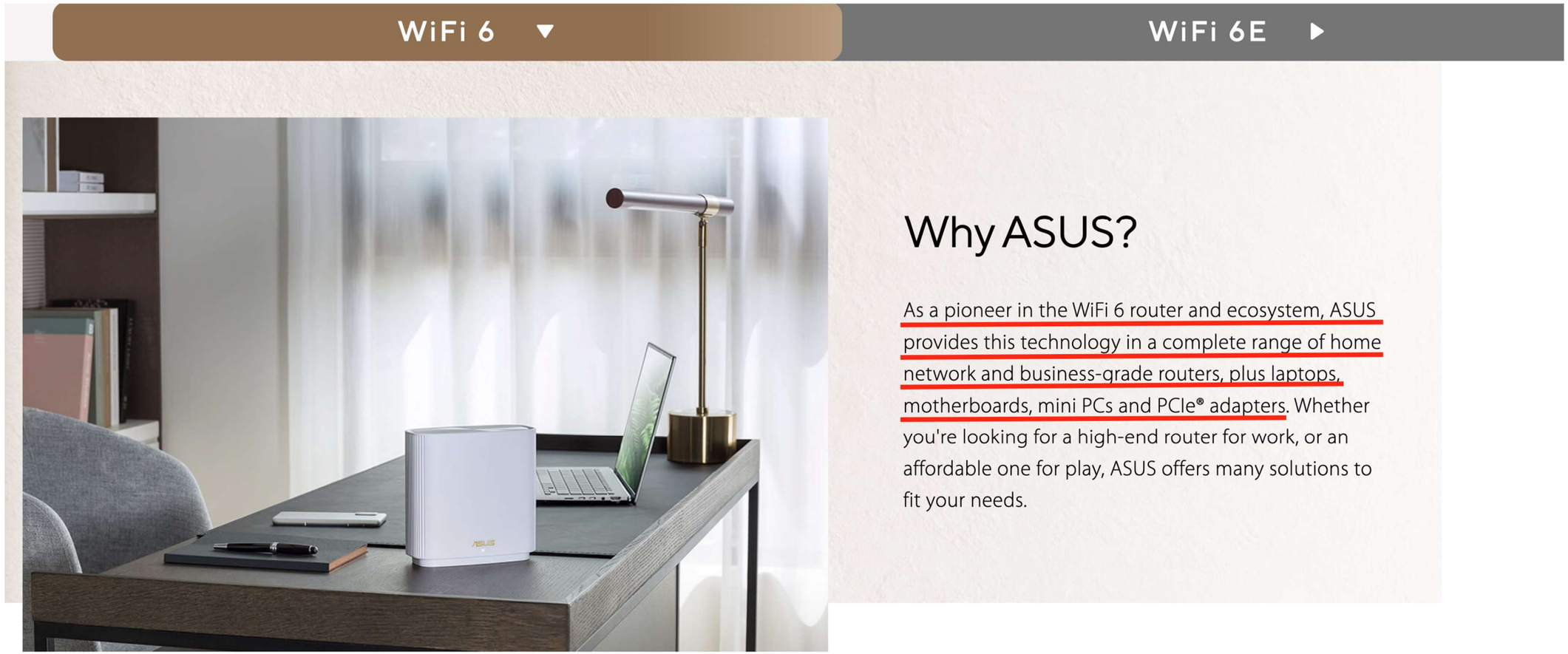
- Asus promotes the use of Asus Wi-Fi routers with Asus end units such as laptops

For example, on the Asus.com website in the video entitled “Explore” about the ASUS ZenWiFi AX (XT8) router



https://www.asus.com/networking-iot-servers/whole-home-mesh-wifi-system/zenwifi-wifi-systems/asus-zenwifi-ax-xt8/

For example, Asus promotes a complete range of Wi-Fi 6 home network and business-grade routers and laptops.



https://www.asus.com/content/wifi6/

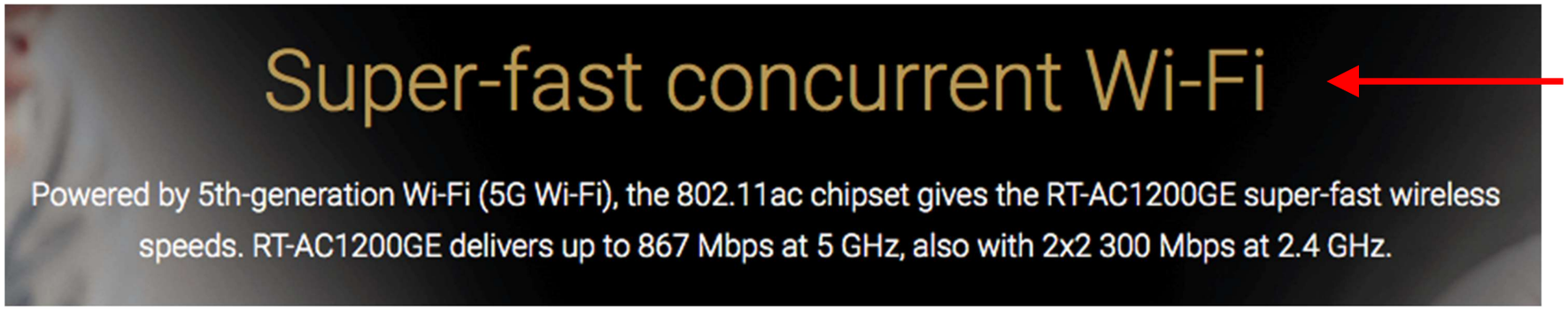
- Additionally, Asus promotes the use of the Asus router app running on an Asus laptop to control configuration settings of Asus routers.

Advanced Configurations

For custom configurations, the ASUS Router app and web interface have powerful tools that let you change system parameters, backhaul type, or node settings. It's a truly professional tool for anyone who wants fully-tailored network settings.

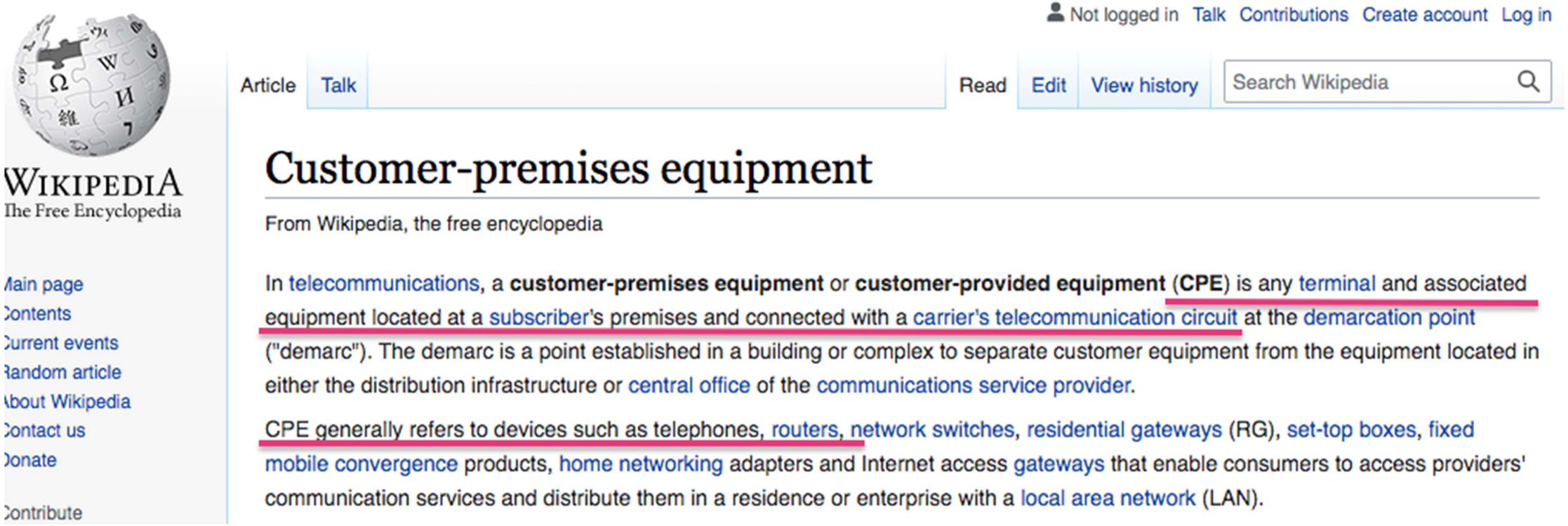
https://www.asus.com/microsite/AiMesh/en/index.html

- **The RT-AC1200GE router is a customer premises system that provides WiFi access**



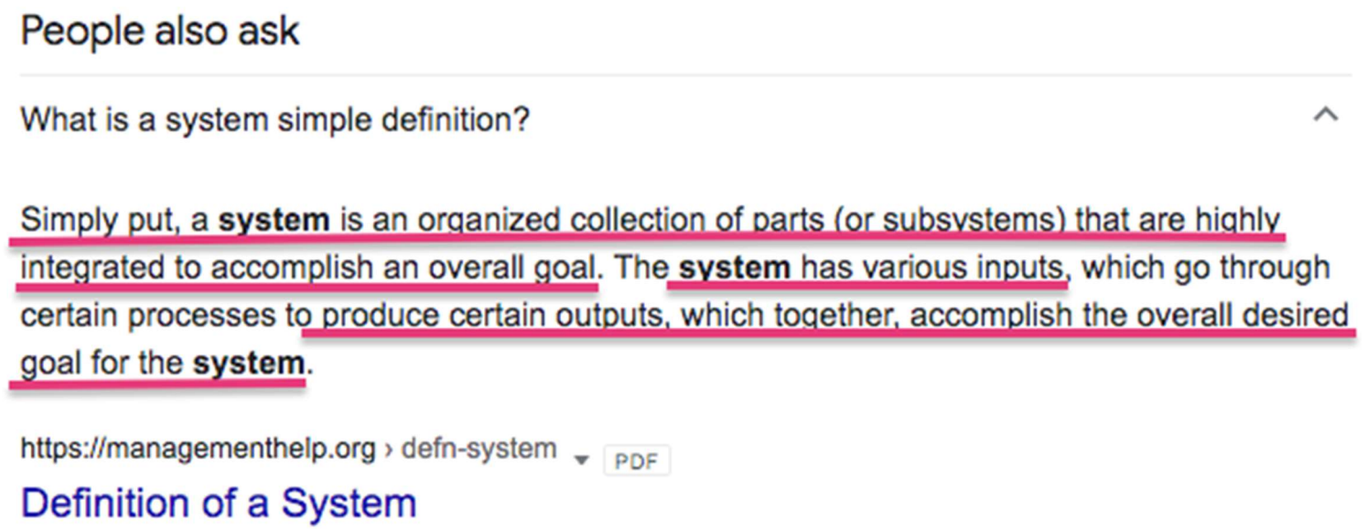
https://www.asus.com/Networking/RT-AC1200GE/

For example, customer premise equipment includes routers:



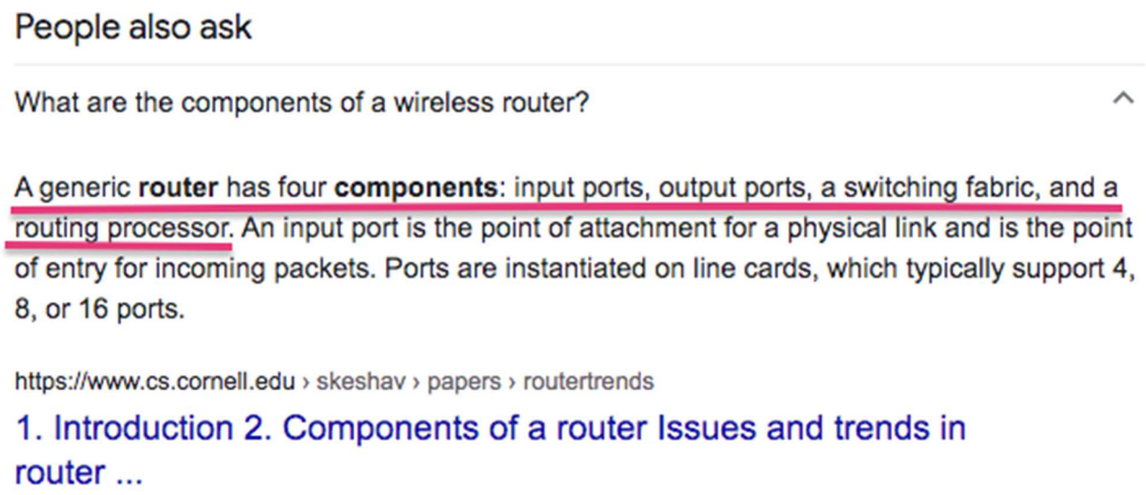
https://en.wikipedia.org/wiki/Customer-premises_equipment

For example, a system is an organized collection of subsystems that are highly integrated to accomplish an overall goal.



https://managementhelp.org/systems/defn-system.pdf

For example, a wireless router is an integrated collection of components (input ports, output ports, switching fabric and a routing processor), which makes it a system. It is used in a home to provide Wi-Fi access. Therefore, a wireless router is a Customer Premise System.



https://www.cs.cornell.edu/skeshav/papers/routertrends.pdf

A **wireless router** connects directly to a modem by a cable. This allows it to receive information from — and transmit information to — the internet. The **router** then creates and communicates with your home **Wi-Fi** network using built-in antennas. As a result, all of the devices on your home network have internet access. Sep. 5, 2019

https://us.norton.com › internetsecurity-iot-smarter-home-...

What is a router, and how does it work? - Norton

https://us.norton.com/internetsecurity-iot-smarter-home-what-is-router.html#:~:text=A%20wireless%20router%20connects%20directly,home%20network%20have%20internet%20access.

According to the patent specification, a customer premise system (also referred to as a wireless distribution system in the patent) does not include end points. For example:

BRIEF SUMMARY OF THE INVENTION

This invention relates to a wireless distribution system for home or business comprising a unitary distribution box, called a wireless multimedia center (WMC), which has inputs for receiving signals from one or more of: a satellite dish; a terrestrial antenna such as a VHF/UHF; a cable line; a telephone or data line such as ISDN, DSL, etc.; and/or fiber optic line, and any other future data or program sources can also be transparently input to the WMC with appropriate modifications or modular plug-ins.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. 1 is a block diagram of a unified multimedia distribution system of the present invention

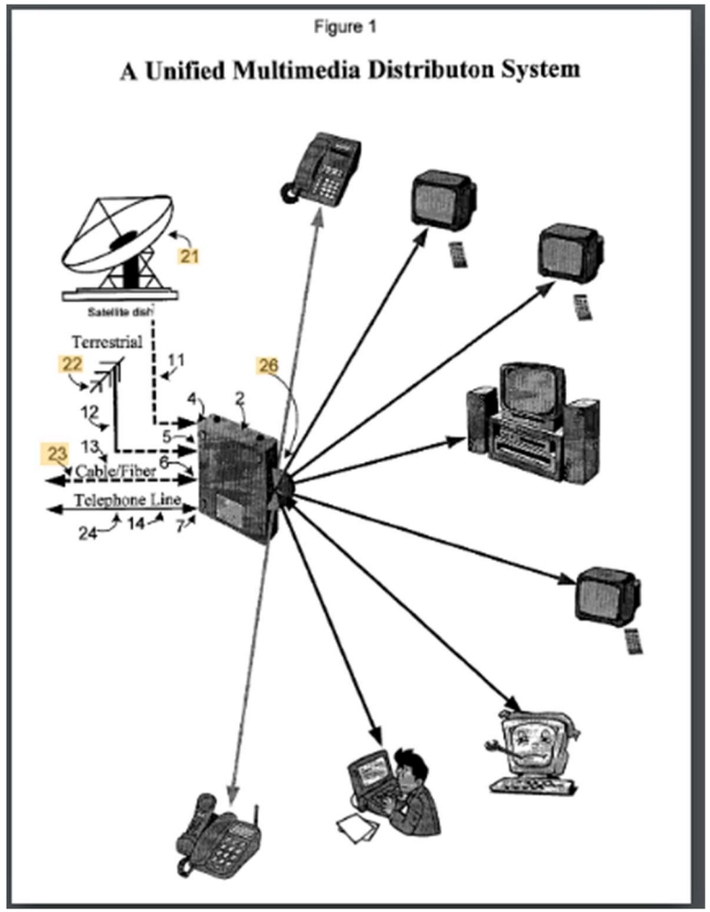
DETAILED DESCRIPTION OF THE INVENTION

As in FIG. 1, this invention relates to a wireless distribution system for home or business, comprising a unitary distribution box **2**, called a wireless multimedia center (WMC), which has inputs for receiving signals **11**-**14** from one or more of:

a satellite dish **21**;
a terrestrial antenna **22**;
a cable input/output line **23**; and/or
a telephone or data line **24** [ISDN, DSL, etc].

Figure 1

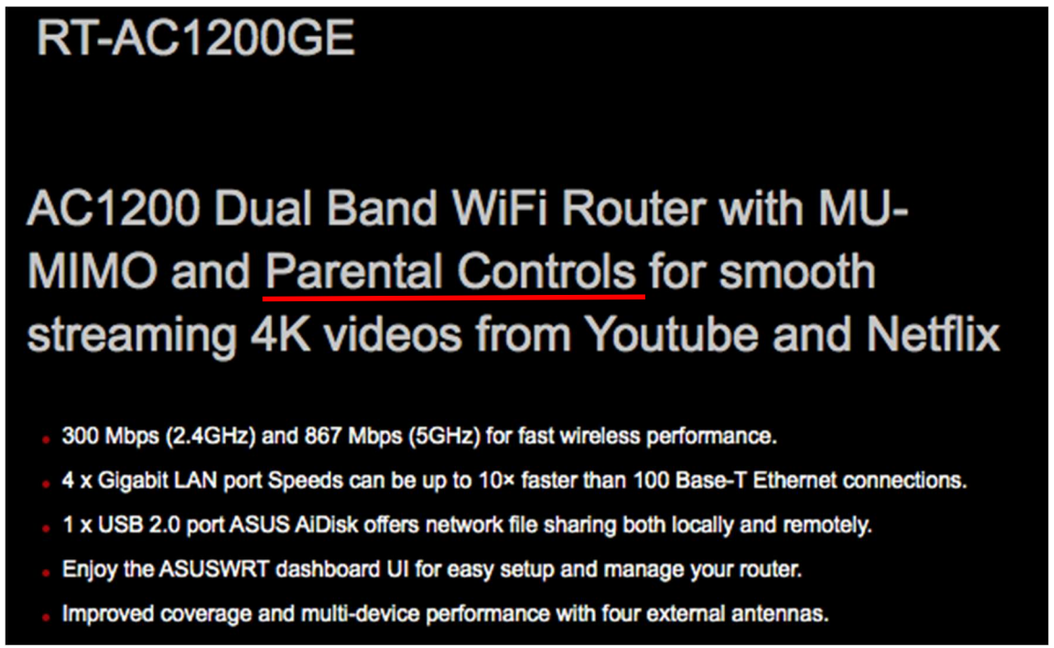
A Unified Multimedia Distributon System



- **The RT-AC1200GE provides WiFi access simultaneously to multiple end units that are located throughout rooms in a building**

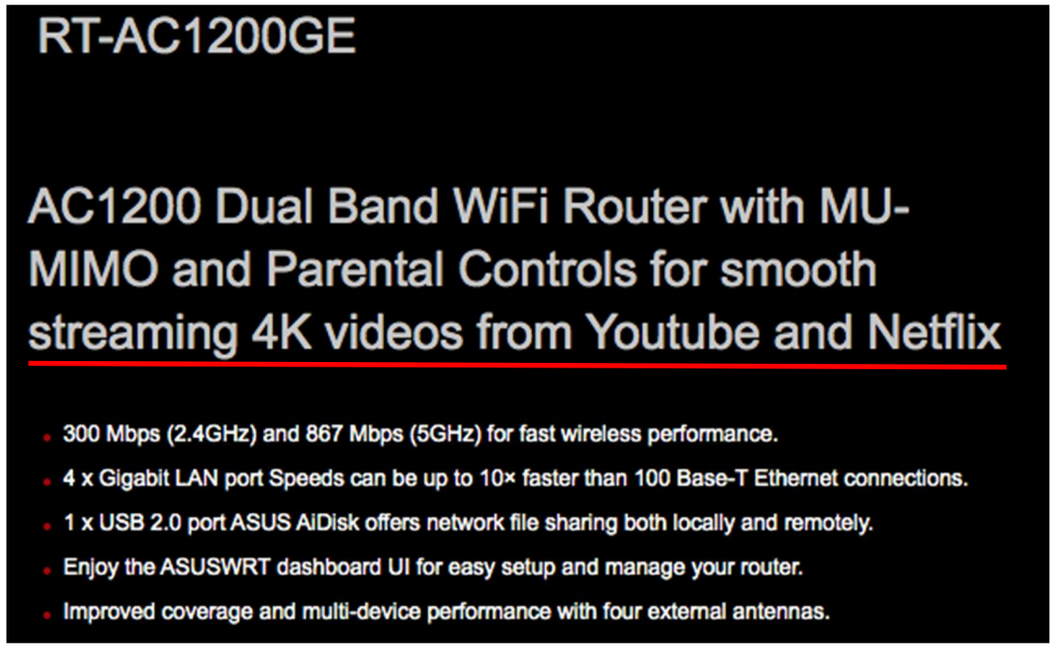
https://www.asus.com/Networking/RT-AC1200GE/

- **The RT-AC1200GE can control which WiFi signals are sent to which end units**



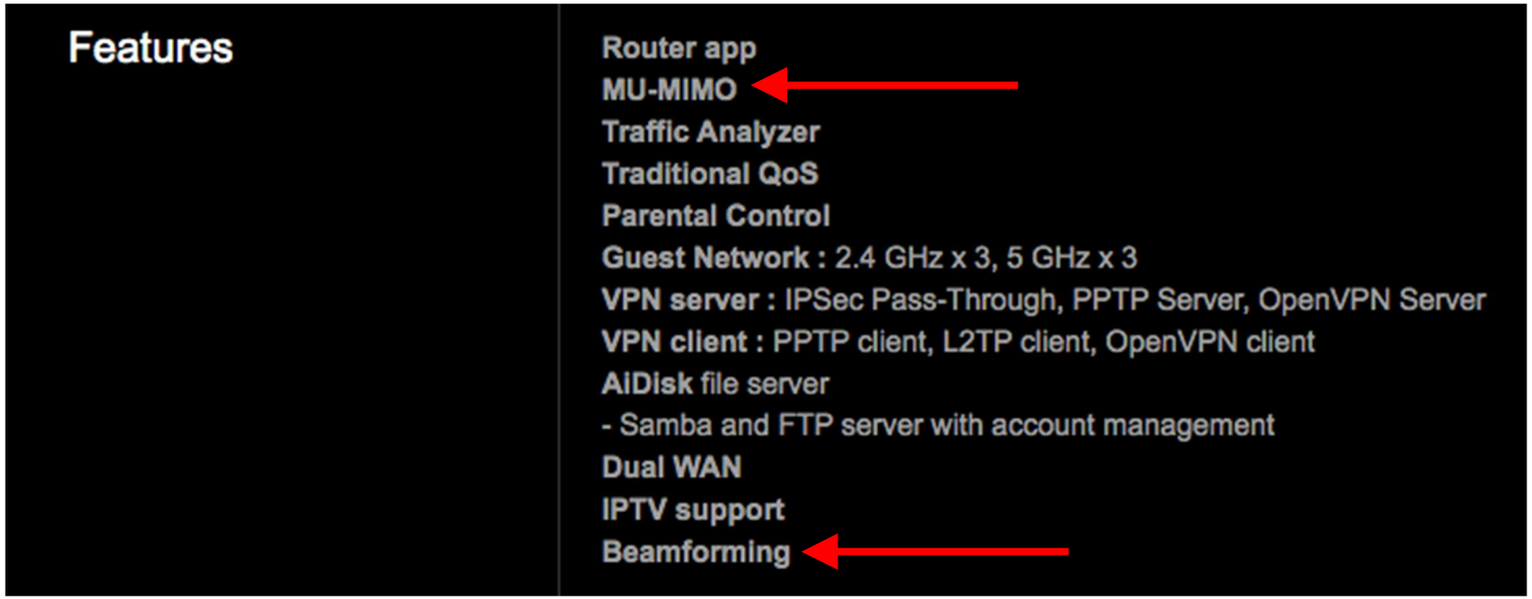
https://www.asus.com/Networking/RT-AC1200GE/

- **The RT-AC1200GE has video streaming capabilities**



https://www.asus.com/Networking/RT-AC1200GE/

➢ **The RT-AC1200GE supports MU-MIMO and beamforming technologies**



https://www.asus.com/Networking/RT-AC1200GE/specifications/

- **The RT-AC1200GE supports the latest advanced WiFi standards (802.11n and 802.11ac) for maximum range and elimination of dead zones**

Network Standard	IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, IEEE 802.11n, IEEE 802.11ac
Product Segment	AC1200 enhanced AC performance : 300+867 Mbps
Coverage	Large homes
Data Rate	802.11a : 6,9,12,18,24,36,48,54 Mbps 802.11b : 1, 2, 5.5, 11 Mbps 802.11g : 6,9,12,18,24,36,48,54 Mbps 802.11n : up to 300 Mbps 802.11ac : up to 867 Mbps

https://www.asus.com/Networking/RT-AC1200GE/specifications/

US9344183 vs. 802.11n/ac (Wi-Fi) Wireless Routers and Access Points

Summary:

This chart compares claims 1 of US9344183 to 802.11n/ac compliant wireless routers and access points. Claim 1 is directed to a system for distributing orthogonal frequency division multiplexing (OFDM) signals carrying multimedia information throughout a multi-room building to multiple end units. A key aspect of the claim that differentiates it from earlier versions of the 802.11 standard (a/b/g) is it requires transmission in multiple directions to multiple end units. This function is supported by multiple-input multiple-output (MIMO) technology, which was introduced in 2009 by 802.11n and later improved in 2013 by 802.11ac. Future versions of the 802.11 standard will also use MIMO technology.

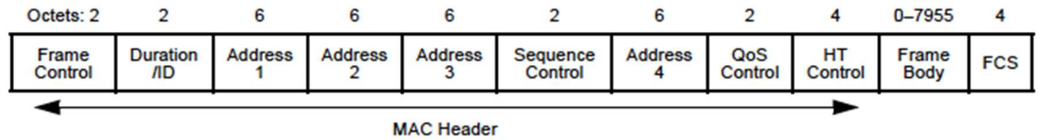
With a priority date of February 29, 2000, US9344183 predates the 802.11ac standard by 13 years and the 802.11n standard by 9 years. These standards use orthogonal frequency division multiplexing as well as multiple-input multiple-output (MIMO) technology both of which compensate for multi-path transmission effects that occur from radio frequency (RF) line of sight (LOS) and RF non-LOS transmission paths, such as occur in multi-room buildings. OFDM technology provides adequate symbol width and guard intervals so as to alleviate inter symbol interference (ISI) effects such as can occur due to multi-path, reflection and absorption phase induced losses. When using broadcast/multicast transmission, 802.11n/ac routers and access points do not expect acknowledgement (ACK) messages from the end-users devices upon the successful reception of packets. In 2009, IEEE 802.11n introduced MIMO directed beamforming techniques, which supported maximum of four space-time streams per transmission. This feature provided the capability to direct transmissions to one or more diversely located end units. IEEE 802.11ac increases the maximum number of space-time streams to eight.

US9344183 – CLAIM 1	***Claim Element Interpretation & Support [patent column: lines]***	***Commentary & Evidence*** **{References at end}**
1. A multimedia device for use in an indoor, multi-room, home or business, building environment, comprising:	The multimedia device is a wireless distribution system for home or business. [1:29-30]	Commentary: IEEE 802.11n/ac wireless distribution systems include 802.11n/ac compliant wireless routers and access points. Evidence: "The single-link and multi-station enhancements supported by **802.11ac** enable several new WLAN usage scenarios, such as **simultaneous streaming of HD video to multiple clients throughout the home**, rapid synchronization and backup of large data files, wireless display, large campus/auditorium deployments, and manufacturing floor automation.[6] With the inclusion of USB 3.0 interface, 802.11ac **access points and routers** can use locally attached storage to provide various services that fully utilize their WLAN capacities, such as video streaming, FTP servers, and personal cloud services.[7] With storage locally attached through USB 2.0, filling the bandwidth made available by 802.11ac was not easily accomplished." {1}
a distribution box located in one of the rooms of the indoor, multi-room, building environment and having at least one input for receiving a signal from at least one of a wireless source and a wired source,	The multimedia device (wireless distribution system) comprises a unitary distribution box, called a wireless multimedia center. [1:29-32] The wireless multimedia center receives signals from various sources such as: a satellite dish, a terrestrial antenna, a DSL or fiber optic line [1:33-34], and transmits segments of the signals to individual transceivers, called end units (EU), located throughout the premises. [1:40-43] The signals are from data or program sources. [1:32-35] Each end unit communicates with	Commentary: An IEEE 802.11n/ac compliant wireless router has a Wide Area Network (WAN) port for connecting to a broadband modem. The broadband modem connects to an Internet service provider via a Cable, DSL, fiber optic line, or terrestrial antenna to receive signals carrying data that provides the Internet service. The Internet service provides many different data and program sources from servers connected to the Internet. The wireless router uses 802.11n/ac (Wi-Fi) to communicate wirelessly to multiple Wi-Fi clients simultaneously. The coverage area of a Wi-Fi network can be extended by connected to the wireless router to multiple Access Points (AP) is physically diverse locations. Evidence: "**Router**: This is the **central device of a home network** into which you can plug one end of a network cable. The other end of the cable goes into a networking device that has a network port. If you want to add more network

US9344183 – CLAIM 1	*Claim Element Interpretation & Support [patent column: lines]*	*Commentary & Evidence* **{References at end}**
	the WMC to control which segments the WMC distributes to the end unit. [Abstract]	devices to a router, you'll need more cables and more ports on the router. These ports, both on the router and on the end devices, are called Local Area Network (LAN) ports." {3} "Wide-area network (WAN) port: Also known as the internet port. Generally, **a router has just one WAN port**. (Some business routers come with dual WAN ports, so one can use two separate internet services at a time.) On any router, the WAN port will be separated from the LAN ports, and is often distinguished by being a different color. **A WAN port is used to connect to an internet source, such as a broadband modem**." {3} "**Broadband modem: Often called a DSL modem or cable modem**, a broadband modem is a device that **bridges the internet connection from a service provider to a computer or to a router**, making the internet available to consumers." {3} "A wireless network is very similar to a wired network with one big difference: **devices don't use cables to connect to the router and one another**. Instead, **they use radio wireless connections called Wi-Fi** (Wireless Fidelity), which is a friendly name for the **802.11** networking standards supported by the Institute of Electrical and Electronics Engineers (IEEE). Wireless networking devices don't need to have ports, just antennas, which sometimes are hidden inside the device itself. In a typical home network, there are generally both wired and wireless devices, and they can all talk to one another. In order **to have a Wi-Fi connection, there needs to be an access point and a Wi-Fi client**." {3} "**Access point**: An access point (AP) is a central device that **broadcasts a Wi-Fi signal for Wi-Fi clients to connect to**. Generally, each wireless network, like those you see popping up on your phone's screen as you walk around a big city, belongs to one access point. You can **buy an AP separately and connect it to a router** or a switch to add Wi-Fi support to a wired network, but generally, you want to **buy a wireless router**, which is a regular router (one WAN port, multiple LAN ports and so on) **with a built-in access point**. Some routers even come with more than one access point (see discussion of dual-band and tri-band routers below)." {3} "**Wi-Fi client**: A Wi-Fi client or WLAN client is a device that can **detect the signal broadcast by an access point**, **connect to it and maintain the connection**. All recent laptops, phones and tablets on the market come with built-in Wi-Fi capability." {3}

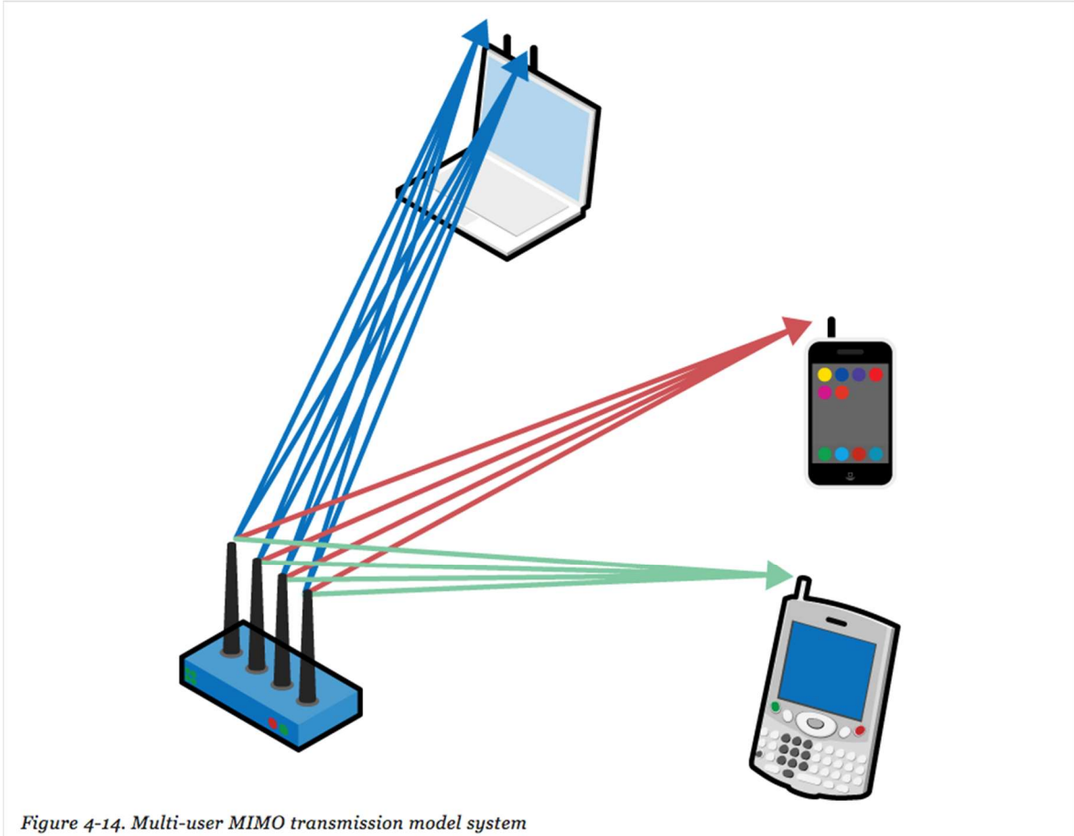
US9344183 – CLAIM 1	***Claim Element Interpretation & Support [patent column: lines]***	***Commentary & Evidence*** **{References at end}**
the signal having at least one of an audio component and a video component; and	The signals include video or audio signals and broadband data. [5: 36-37] The signals provide distribution of multiple services such as telephone, radio, television, digital data, and Internet throughout the location by wireless digital transmission to end units. [4:64-5:2]	Commentary: The wireless signals transmitted by an 802.11n/ac compliant wireless router or access point include signals for video streaming and broadband data communications. Evidence: **"802.11ac** is the latest evolution of Wi-Fi, and it should be particularly good for **gaming and HD video streaming**." {4} "The single-link and multi-station enhancements supported by **802.11ac** enable several new WLAN usage scenarios, such as **simultaneous streaming of HD video to multiple clients throughout the home**, rapid **synchronization and backup of large data files**, wireless display, large campus/auditorium deployments, and manufacturing floor automation." {1} "The last major revision to the main WiFi standard was **802.11ac**, which was designed to dramatically increase the speed of **data transfers**. This is the first standard on the way to "Gigabit WiFi" where speeds can reach 1 Gbit/s, by far the fastest WiFi version to date. 802.11ac also runs solely on the less cluttered 5 GHz band and this higher frequency and modulation rate allows for a higher speed, at the expense of range compared with 2.4 GHz 802.11n or g." {5}
an orthogonal frequency division multiplexing (OFDM) transceiver operatively connected to the at least one input of the distribution box,	Signals input to the multimedia device (wireless multimedia center) are then re-broadcast using OFDM technology throughout the premises. These signals are transmitted to and received by individual transceivers, called end units (EU), located throughout the premises. [1:38-43] The video signals are broadcast to one or more end units. [5:48] The OFDM that carries the video	Commentary: IEEE 802.11 n/ac routers and access points use OFDM transmission techniques. They also supports MIMO transmission, which uses multiple input and multiple output antennas to improve signal transmission in indoor environments. MIMO also provides beamforming capabilities. Evidence: "Traditionally, radio engineers treated natural multipath propagation as an impairment to be mitigated. **MIMO** is the first radio technology that treats **multipath propagation** as a phenomenon to be exploited. MIMO multiplies the capacity of a radio link by transmitting multiple signals over multiple, co-located antennas. This is

US9344183 – CLAIM 1	***Claim Element Interpretation & Support [patent column: lines]***	***Commentary & Evidence*** **{References at end}**
	signals may be coded orthogonal frequency division multiple access (COFDMA). [6:22-23]	accomplished without the need for additional power or bandwidth. **Space–time codes are employed to ensure that the signals transmitted over the different antennas are orthogonal to each other, making it easier for the receiver to distinguish one from another.** Even when there is line of sight access between two stations, dual antenna polarization may be used to ensure that there is more than one robust path. **OFDM** enables reliable broadband communications by **distributing user data across a number of closely spaced, narrowband subchannels**.[1] This arrangement makes it possible to eliminate the biggest obstacle to reliable broadband communications, intersymbol interference (ISI). ISI occurs when the overlap between consecutive symbols is large compared to the symbols' duration. Normally, high data rates require shorter duration symbols, increasing the risk of ISI. By dividing a high-rate data stream into numerous low-rate data streams, **OFDM enables longer duration symbols**. A cyclic prefix (CP) may be inserted to create a (time) guard interval that prevents ISI entirely. If the guard interval is longer than the delay spread—the difference in delays experienced by symbols transmitted over the channel—then there will be no overlap between adjacent symbols and consequently no intersymbol interference. Though the CP slightly reduces spectral capacity by consuming a small percentage of the available bandwidth, the elimination of ISI makes it an exceedingly worthwhile tradeoff. "{6}
and operative for wirelessly and unidirectionally broadcasting the signal using OFDM modulation inside the indoor, multi-room, building environment	The definition of broadcasting data packets is well known to those skilled in the art of data communications. This patent claims priority from counterpart patent US7827581, which incorporated into this patent (US9344183) by reference. US7827581 includes a definition of broadcasting data packets. This explicit definition is consistent with the accepted meaning of the term. According to this definition, broadcasting digital data packets to transmit digital data packets in one direction (unidirectionally), with no hand-	<u>Commentary regarding broadcasting:</u> IEEE 802.11n/ac supports broadcast transmission of data frames, in which case there the receiving end unit does not send an acknowledgement when it receives a data frame. In IEEE 802.11n (2009) the nomenclature for broadcast and multicast frames changed to "group addressed" frames. Generally, group addressed frames are frames that are addressed to more than one destination. The Quality of Service (QoS) control field of a data frame is a 16-bit field that identifies the traffic category or traffic stream to which the frame belongs and other QoS-related information about the frame. The Ack Policy subfield (bits 5 and 6) of the QoS control field is used to specify whether or not the data frame requires an acknowledgement. The combination of bit 5 = 1 and bit 6 = 0 is used for group addressed data frames to indicate that an acknowledgement is not required for the data frame. Live streaming, such as sport events etc., frequently use Real Time Streaming Protocol (which runs over Real-time Transport Protocol, which in turn runs over UDP – User Datagram Protocol) because time delays can not be tolerated. Hence UDP is used because it does not perform retransmissions to correct data transmission errors nor does it perform handshaking between the transmitting station and receiving station. {12} {13} {14} Therefore, such transmission are broadcast transmissions as defined by the patent specification (note that US7827581, which specifically defines broadcasting as transmissions that do not perform handshaking is incorporated by

US9344183 – CLAIM 1	*Claim Element Interpretation & Support [patent column: lines]*	*Commentary & Evidence* **{References at end}**
	shaking mechanism for each digital data packet. In the example of a residential property, the services are distributed throughout a house. A single multimedia device (wireless multimedia center) distributes the services shown in Fig. 5 to end units located in the various rooms of the home. [3:36-40]	reference into US9344183) and are spatially unidirectional by virtue of beamforming as described in the next section of this chart. <u>Evidence regarding broadcasting:</u> "**Frames transmitted to a broadcast** or multicast destination (Address 1 has the group bit set) have a duration of 0. Such frames are not part of an atomic exchange and **are not acknowledged by receivers**, so contention-based access to the medium can begin after the conclusion of a broadcast or multicast data frame." {2}  **Figure 7-1—MAC frame format** {8} **7.1.3.5 QoS Control field** "The QoS Control field is a 16-bit field that identifies the **traffic category** (TC) or **traffic stream** (TS) to which the frame belongs and various other **QoS-related information** about the frame that varies by frame type and subtype." {8} **7.1.3.5.3 Ack Policy subfield** **Table 7-6—Ack Policy subfield in QoS Control field of QoS data frames** **Bits in QoS Control field** | **Meaning** **Bit 5** | **Bit 6**

US9344183 – CLAIM 1	*Claim Element Interpretation & Support [patent column: lines]*	*Commentary & Evidence* **{References at end}**
		<table><tr><td>1</td><td>0</td><td>No Ack The addressed recipient takes no action upon receipt of the frame. More details are provided in 9.11. The Ack Policy subfield is set to this value in all directed frames in which the sender does not require acknowledgment. This combination is also used for ~~broadcast and multicast~~ group-addressed frames that use the QoS frame format. This combination is not used for QoS data frames with a TID for which a Block Ack agreement exists.</td></tr></table> {8}
from the distribution box in the room in multiple directions	The limitation regarding "in multiple directions to a plurality of end units", is taken to mean that the broadcast transmission is directionally specific as opposed to being omnidirectional. The transmission is made in the direction of the end units. Furthermore, the wireless multimedia center is capable of directing a transmission to a specific end unit. An end unit informs the WMC of the signal segment that the end unit is to receive. The WMC then directs a transmission of that signal segment, which is receivable by the end unit, to that end unit. [2:65-3:2]. One of the dimensions of the transmission is direction. [6:50]	Commentary In 2009, IEEE 802.11n introduced MIMO transmission capability, which supports directed beamforming. Beamforming enables transmissions to be spatially directed to a one or more diversely located receivers. In 2013, IEEE 802.11ac extended the maximum number of space-time streams supported from four streams in 802.11n to eight in 802.11ac. The Very High Throughput (VHT) physical specification (PHY) of 802.11ac applies to individually addressed and group addressed transmission (see the earlier discussion regarding broadcast/multicast transmissions now referred to as group addressed transmissions). The VHT PHY also provides support for downlink multi-user (MU) transmissions. A downlink MU transmission supports up to four users with up to four space-time streams per user with the total number of space-time streams not exceeding eight. The following figure depicts directed space-time streams being transmitted to end units. Note that either the transmission depicted by the blue arrows (i.e. eight streams) or the transmission depicted by the green arrows and the red arrows (i.e. total of eight streams) would occur simultaneously, so as not to exceed the maximum of eight streams. Evidence: **"22. Very High Throughput (VHT) PHY specification** **22.1 Introduction** **22.1.1 Introduction to the VHT PHY** Clause 22 specifies the PHY entity for a very high throughput (VHT) orthogonal frequency division multiplexing (**OFDM**) system.

US9344183 – CLAIM 1	***Claim Element Interpretation & Support [patent column: lines]***	***Commentary & Evidence*** **{References at end}**
		In addition to the requirements in Clause 22, a VHT STA shall be capable of transmitting and receiving PPDUs that are compliant with the mandatory PHY specifications defined in Clause 20. The VHT PHY is based on the HT PHY defined in Clause 20, which in turn is based on the OFDM PHY defined in Clause 18. The VHT PHY extends the maximum number of **space-time streams** supported to eight and provides support for downlink multi-user (MU) transmissions. A downlink MU transmission **supports up to four users with up to four space-time streams per user** with the total number of space-time streams not exceeding eight. NOTE—A VHT SU PPDU includes individually addressed and **group addressed transmissions**." {9}

US9344183 – CLAIM 1	*Claim Element Interpretation & Support [patent column: lines]*	*Commentary & Evidence* {References at end}
		 *Figure 4-14. Multi-user MIMO transmission model system* {7}
to a plurality of end units,	The signals received by the WMC are transmitted to the end units. There are a	Commentary:

<table>
<tr><th>US9344183 – CLAIM 1</th><th>Claim Element Interpretation & Support [patent column: lines]</th><th>Commentary & Evidence {References at end}</th></tr>
<tr><td></td><td>wide variety of end units that may receive signals from the WMC. The end units include video end units (VEU), e.g. for TV and radio, and communication end units (CEU), e.g. for telephone and data. [1:38-45] A video end unit may be a set-top box or may be incorporated in a TV. [2:31-33] A communications end unit may be separate boxes with various ports such as: serial, parallel, USB, Ethernet, IEEE 1394 or telephone-and/or-fax-and/or-modem. Alternatively, communications end unit PC card may be inserted into a computer. [2:48-52] End units may be adapted to Internet communication terminals, laptop computers, or personal information managers. [2:53-55] An end unit can be universal, analog, digital or both, communications, or any combination. [2:40-41]</td><td>An IEEE 802.11n/ac compliant wireless router or access point is capable of communicating with many types of end units. Examples of the various types of end units, which are 802.11n/ac compliant Wi-Fi client devices is given in the table below. These Wi-Fi client devices include handheld devices, laptops, tablets, PCs, digital TVs and set-top boxes.

Evidence:

<table>
<tr><th>Scenario</th><th>Typical client form factor</th><th>PHY link rate</th><th>Aggregate capacity (speed)</th></tr>
<tr><td>One-antenna AP, one-antenna STA, 80 MHz</td><td>Handheld</td><td>433 Mbit/s</td><td>433 Mbit/s</td></tr>
<tr><td>Two-antenna AP, two-antenna STA, 80 MHz</td><td>Tablet, laptop</td><td>867 Mbit/s</td><td>867 Mbit/s</td></tr>
<tr><td>One-antenna AP, one-antenna STA, 160 MHz</td><td>Handheld</td><td>867 Mbit/s</td><td>867 Mbit/s</td></tr>
<tr><td>Three-antenna AP, three-antenna STA, 80 MHz</td><td>Laptop, PC</td><td>1.27 Gbit/s</td><td>1.27 Gbit/s</td></tr>
<tr><td>Two-antenna AP, two-antenna STA, 160 MHz</td><td>Tablet, laptop</td><td>1.69 Gbit/s</td><td>1.69 Gbit/s</td></tr>
<tr><td>Four-antenna AP, four one-antenna STAs, 160 MHz (MU-MIMO)</td><td>Handheld</td><td>867 Mbit/s to each STA</td><td>3.39 Gbit/s</td></tr>
<tr><td>Eight-antenna AP, 160 MHz (MU-MIMO)
. one four-antenna STA
. one two-antenna STA
. two one-antenna STAs</td><td>Digital TV, Set-top Box, Tablet, Laptop, PC, Handheld</td><td>. 3.39 Gbit/s to four-antenna STA
. 1.69 Gbit/s to two-antenna STA
. 867 Mbit/s to each one-antenna STA</td><td>6.77 Gbit/s</td></tr>
<tr><td>Eight-antenna AP, four 2-antenna STAs, 160 MHz (MU-MIMO)</td><td>Digital TV, tablet, laptop, PC</td><td>1.69 Gbit/s to each STA</td><td>6.77 Gbit/s</td></tr>
</table>
{1}</td></tr>
<tr><td>at least one of the end units being located in another room separated by a wall from the one room of the indoor, multi-room, building environment,</td><td>In the example of a residential property, the services are distributed throughout a house. A single multimedia device (wireless multimedia center) distributes the services</td><td>Commentary:

Transmissions from IEEE 802.11n/ac compliant routers and access points are capable of passes through walls of an indoor, multi-room building. The excerpt from the referenced research paper describes an office scenario in which an 802.11ac access point was tested. The access point is depicted as a blue square in the figure. Wireless devices at locations E, G, and H receive non-line of sight transmissions through at least one interior wall. IEEE</td></tr>
</table>

US9344183 – CLAIM 1	***Claim Element Interpretation & Support [patent column: lines]***	***Commentary & Evidence*** **{References at end}**
	shown in Fig. 5 to end units located in the various rooms of the home. [3:36-40]	802.11n routers and access points are thought to have better wall penetration capability than similar 802.11ac systems because they transmit at 2.4 GHz, as compared to 802.11ac systems, which transmit at 5 GHz. Although some 802.11ac routers and access point support dual frequencies – 2.4Ghz and 5 GHz. <u>Evidence:</u> "3. 802.11AC THROUGHPUT & JITTER PERFORMANCE CHARACTERIZATION 3.1 Office scenario We deploy an **indoor 802.11ac WLAN testbed** in our offices, covering an area of 40×15m2. The office testbed is depicted in Fig. 1 with **the blue square indicating the AP and the red circles the clients**. The **average RSSI** and other characteristics **of each client** evaluated in the office testbed are **described in Table 1**. "{10}

US9344183 – CLAIM 1	*Claim Element Interpretation & Support [patent column: lines]*	*Commentary & Evidence* {References at end}

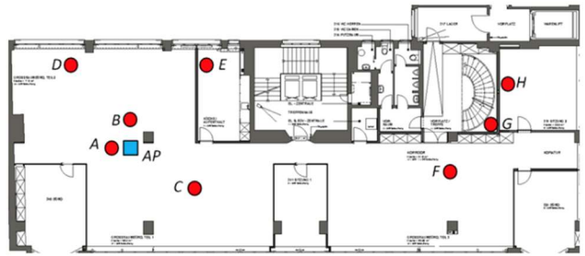


Figure 1: 802.11ac office testbed used for the throughput and latency measurements. The blue square indicates the access point and a red circle a client.

Link	RSSI	Line of Sight	Quality
A	-10 dBm	Yes	Strong
B	-14 dBm	Yes	Strong
C	-27 dBm	No	Strong
D	-40 dBm	No	Medium
E	-45 dBm	No	Medium
F	-57 dBm	No	Medium
G	-61 dBm	No	Weak
H	-75 dBm	No	Weak

Table 1: Average RSSI values for each link type in the office testbed, when using channel 149. {10}

"5Ghz does have a downside in that it is less able to penetrate solid walls and objects, so if you go outside your house to use your phone, your connection might drop. So to sum up, 2.4Ghz is very congested resulting in dropped connections and slow data throughput. However, it is better suited for transmitting data over longer ranges and through walls and other solid objects. 5Ghz by contrast, is what we'll call the "indoor" band. It's ideal for connections inside the house due to the lack of congestion, higher data transmission rates, and smaller

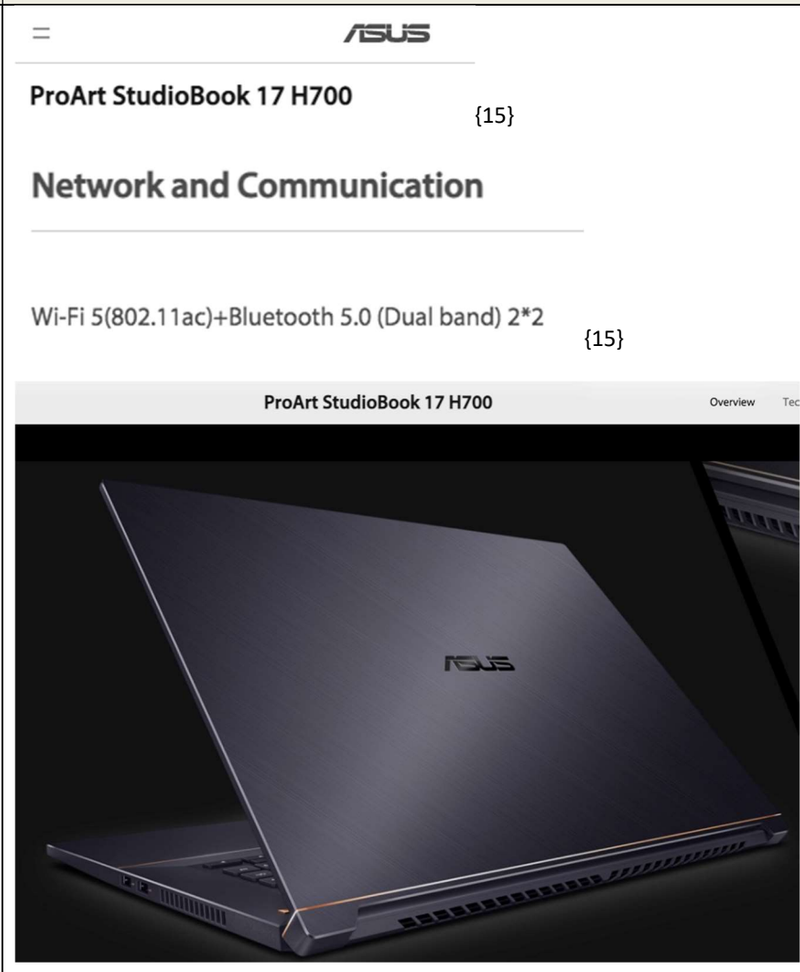
US9344183 – CLAIM 1	***Claim Element Interpretation & Support [patent column: lines]***	***Commentary & Evidence*** **{References at end}**
		effective range. It's also the only band available if you want to take advantage of the newer, super-fast wireless AC standard. {11}
the at least one end unit receiving the unidirectionally broadcast signal through the wall via packets each having a width of sufficient duration to resist multi-path reflection and absorption phase induced losses.	Signals input to the multimedia device (wireless multimedia center) are then re-broadcast using OFDM technology throughout the premises. These signals are transmitted to and received by individual transceivers, called end units (EU), located throughout the premises. [1:38-43] All of the signals are added together and summed as an orthogonal array having dimensions of time, frequency and amplitude, to transmit spread spectrum multiplexed signals, in which each pulse including said signals has sufficiently long individual pulse widths to defeat multi-path, reflection and absorption phase induced losses. [5:42-47]	Commentary: IEEE 802.11n/ac compliant routers and access points use OFDM transmission techniques that enable the transmission to resist multi-path reflection and absorption phase induced losses. The first references compares 802.11ac transmission testing (link quality) results between an office testbed, in which the interior walls were made of concrete and steel, to a home testbed, in which the interior walls were made of wood. In both cases the transmissions penetrated the interior walls, even though the walls made of concrete and steel provided a higher degree of reflections and multi-path effects. The second reference describes how OFDM signals resist these effects. Specifically, by distributing the data across multiple subchannels, the data rate on each subchannel is slow enough that the transmitted data symbols are of long enough duration to resist intersymbol interference, which is caused by the effects of multi-path reflection and absorption phase induced losses. Therefore, the transmitted packets, which comprise these symbols, are of sufficient duration to resist these effects. Evidence: "3.2 Home scenario To validate that the results presented in §3.1 are consistent in more than one testbed, we repeat the same characterization with the same methodology in a **home testbed** covering an area of 18 × 15m2 (mainly built of wood). The links evaluated are described in Table 4. Note that **we examined multiple different areas of the home environment but there was not high variation in link qualities** and therefore we only present four links. We see that the trend of the office regression (Fig. 3) heatmaps is similar is followed also in the case of the home testbed (Fig. 4). However, the trend for each feature in the home testbed is much clearer and more monotonic and consistent across the different link qualities because of the lack of high human interference, as well as the

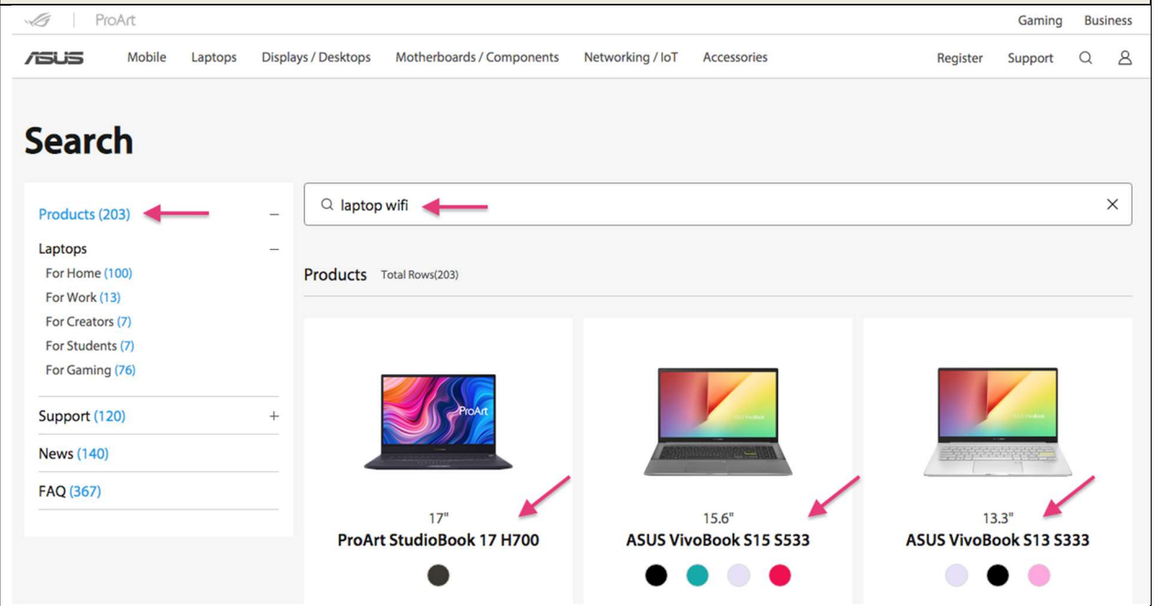
US9344183 – CLAIM 1	*Claim Element Interpretation & Support [patent column: lines]*	*Commentary & Evidence* **{References at end}**
		material (wood) the home testbed is made of – compared to the office one (concrete, steel) – minimizing the impact of reflections and multipath. "{10} **"OFDM** enables reliable broadband communications by **distributing user data across a number of closely spaced, narrowband subchannels**.[1] This arrangement **makes it possible to eliminate the biggest obstacle to reliable broadband communications, intersymbol interference (ISI)**. ISI occurs when the overlap between consecutive symbols is large compared to the symbols' duration. **Normally, high data rates require shorter duration symbols, increasing the risk of ISI. By dividing a high-rate data stream into numerous low-rate data streams, OFDM enables longer duration symbols**. A cyclic prefix (CP) may be inserted to create a (time) guard interval that prevents ISI entirely. If the guard interval is longer than the delay spread—the difference in delays experienced by symbols transmitted over the channel—then there will be no overlap between adjacent symbols and consequently no intersymbol interference. Though the CP slightly reduces spectral capacity by consuming a small percentage of the available bandwidth, the elimination of ISI makes it an exceedingly worthwhile tradeoff. "{6}

US9344183 – CLAIM 7	***Claim Element Interpretation & Support [patent column: lines]***	***Commentary & Evidence*** **{References at end}**
7. A multimedia system, comprising:	The multimedia device is a wireless distribution system for home or business. [1:29-30]	Commentary: IEEE 802.11n/ac wireless distribution systems include 802.11n/ac compliant wireless routers and access points. Evidence: "The single-link and multi-station enhancements supported by **802.11ac** enable several new WLAN usage scenarios, such as **simultaneous streaming of HD video to multiple clients throughout the home**, rapid synchronization and backup of large data files, wireless display, large campus/auditorium deployments, and manufacturing floor automation.[6] With the inclusion of USB 3.0 interface, 802.11ac **access points and routers** can use locally attached storage to provide various services that fully utilize their WLAN capacities, such as video streaming, FTP servers, and personal cloud services.[7] With storage locally attached through USB 2.0, filling the bandwidth made available by 802.11ac was not easily accomplished." {1}
a distribution box located in one room of an indoor, multi-room, home or business building environment and having at least one input for receiving a signal from at least one of a wireless source and a wired source,	The multimedia device (wireless distribution system) comprises a unitary distribution box, called a wireless multimedia center. [1:29-32] The wireless multimedia center receives signals from various sources such as: a satellite dish, a terrestrial antenna, a DSL or fiber optic line [1:33-34], and transmits segments of the signals to individual transceivers, called end units (EU), located throughout the premises. [1:40-43] The signals are from data or program sources. [1:32-35] Each end unit communicates with the WMC to control which segments the WMC distributes to the end unit. [Abstract]	Commentary: An IEEE 802.11n/ac compliant wireless router has a Wide Area Network (WAN) port for connecting to a broadband modem. The broadband modem connects to an Internet service provider via a Cable, DSL, fiber optic line, or terrestrial antenna to receive signals carrying data that provides the Internet service. The Internet service provides many different data and program sources from servers connected to the Internet. The wireless router uses 802.11n/ac (Wi-Fi) to communicate wirelessly to multiple Wi-Fi clients simultaneously. The coverage area of a Wi-Fi network can be extended by connected to the wireless router to multiple Access Points (AP) is physically diverse locations. Evidence: "**Router**: This is the **central device of a home network** into which you can plug one end of a network cable. The other end of the cable goes into a networking device that has a network port. If you want to add more network

US9344183 – CLAIM 7	*Claim Element Interpretation & Support [patent column: lines]*	*Commentary & Evidence* **{References at end}**
		devices to a router, you'll need more cables and more ports on the router. These ports, both on the router and on the end devices, are called Local Area Network (LAN) ports." {3} "Wide-area network (WAN) port: Also known as the internet port. Generally, **a router has just one WAN port**. (Some business routers come with dual WAN ports, so one can use two separate internet services at a time.) On any router, the WAN port will be separated from the LAN ports, and is often distinguished by being a different color. **A WAN port is used to connect to an internet source, such as a broadband modem**." {3} "**Broadband modem: Often called a DSL modem or cable modem**, a broadband modem is a device that **bridges the internet connection from a service provider to a computer or to a router**, making the internet available to consumers." {3} "A wireless network is very similar to a wired network with one big difference: **devices don't use cables to connect to the router and one another**. Instead, **they use radio wireless connections called Wi-Fi** (Wireless Fidelity), which is a friendly name for the **802.11** networking standards supported by the Institute of Electrical and Electronics Engineers (IEEE). Wireless networking devices don't need to have ports, just antennas, which sometimes are hidden inside the device itself. In a typical home network, there are generally both wired and wireless devices, and they can all talk to one another. In order **to have a Wi-Fi connection, there needs to be an access point and a Wi-Fi client**." {3} "**Access point**: An access point (AP) is a central device that **broadcasts a Wi-Fi signal for Wi-Fi clients to connect to**. Generally, each wireless network, like those you see popping up on your phone's screen as you walk around a big city, belongs to one access point. You can **buy an AP separately and connect it to a router** or a switch to add Wi-Fi support to a wired network, but generally, you want to **buy a wireless router**, which is a regular router (one WAN port, multiple LAN ports and so on) **with a built-in access point**. Some routers even come with more than one access point (see discussion of dual-band and tri-band routers below)." {3} "**Wi-Fi client**: A Wi-Fi client or WLAN client is a device that can **detect the signal broadcast by an access point**, **connect to it and maintain the connection**. All recent laptops, phones and tablets on the market come with built-in Wi-Fi capability." {3}

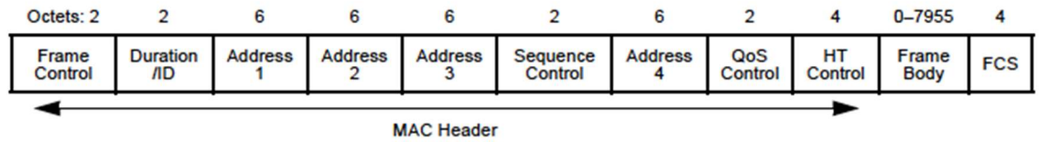
US9344183 – CLAIM 7	***Claim Element Interpretation & Support [patent column: lines]***	***Commentary & Evidence*** **{References at end}**
the signal having at least one of an audio component and a video component;	The signals include video or audio signals and broadband data. [5: 36-37] The signals provide distribution of multiple services such as telephone, radio, television, digital data, and Internet throughout the location by wireless digital transmission to end units. [4:64-5:2]	Commentary: The wireless signals transmitted by an 802.11n/ac compliant wireless router or access point include signals for video streaming and broadband data communications. Evidence: **"802.11ac** is the latest evolution of Wi-Fi, and it should be particularly good for **gaming and HD video streaming**." {4} "The single-link and multi-station enhancements supported by **802.11ac** enable several new WLAN usage scenarios, such as **simultaneous streaming of HD video to multiple clients throughout the home**, rapid **synchronization and backup of large data files**, wireless display, large campus/auditorium deployments, and manufacturing floor automation." {1} "The last major revision to the main WiFi standard was **802.11ac**, which was designed to dramatically increase the speed of **data transfers**. This is the first standard on the way to "Gigabit WiFi" where speeds can reach 1 Gbit/s, by far the fastest WiFi version to date. 802.11ac also runs solely on the less cluttered 5 GHz band and this higher frequency and modulation rate allows for a higher speed, at the expense of range compared with 2.4 GHz 802.11n or g." {5}
a plurality of end units, at least one of the end units being located in another room separated by a wall from the one room of the indoor, multi-room building environment; and	As in FIG. 2, these signals are transmitted to, and received by, individual transceivers **31**-**36** located throughout the premises. These transceivers are presently contemplated as: ○ video end unit **31**-**33**, for ▪ television receivers **41**-**43**;	Commentary: Asus makes and sells over 200 models of laptops that support Wi-Fi standards such as 802.11ac. These laptops meet the requirements of the recited end units such as communications end units described in the patent specification, for example computers. Evidence:

US9344183 – CLAIM 7	*Claim Element Interpretation & Support [patent column: lines]*	*Commentary & Evidence* **{References at end}**
	▪ VCRs; ▪ AM/FM broadcasting; ○ Communications end unit **34**-**36**, for: ▪ computers **46**; ▪ telephones **36**, ▪ faxes, ▪ answering machines, ▪ other telephonic devices, and ▪ any other electronic apparatus. In FIG. 5, Example: Residential Property, the services distributed throughout a house **120** are indicated. In this residential property example, a single WMC distributes the services shown to end units located as indicated **121**-**125** in the various rooms.	 {15}

US9344183 – CLAIM 7	*Claim Element Interpretation & Support [patent column: lines]*	*Commentary & Evidence* **{References at end}**
		 {16} Some example models are: ProArt StudioBook 17 H700 ASUS VivoBook S15 S533 ASUS VivoBook S13 S333

US9344183 – CLAIM 7	***Claim Element Interpretation & Support [patent column: lines]***	***Commentary & Evidence*** **{References at end}**
		ASUS ZenBook 15 UX534 ASUS ExpertBook B9 B9450 ASUS Chromebook Flip C436 ProArt StudioBook 15 H500 ProArt StudioBook Pro 15 W500 ZenBook Duo UX481 ProArt StudioBook Pro X W730 ProArt StudioBook Pro 17 W700 ASUS VivoBook S15 S532 ASUS M415 (AMD Ryzen 5000 Series) ASUS M515 (AMD Ryzen 5000 Series) ASUS L410 ASUS L210 ASUS L510 R543 ASUS BR1100C

US9344183 – CLAIM 7	***Claim Element Interpretation & Support [patent column: lines]***	***Commentary & Evidence*** **{References at end}**
an orthogonal frequency division multiplexing (OFDM) transceiver operatively connected to the at least one input of the distribution box,	Signals input to the multimedia device (wireless multimedia center) are then re-broadcast using OFDM technology throughout the premises. These signals are transmitted to and received by individual transceivers, called end units (EU), located throughout the premises. [1:38-43] The video signals are broadcast to one or more end units. [5:48] The OFDM that carries the video signals may be coded orthogonal frequency division multiple access (COFDMA). [6:22-23]	Commentary: IEEE 802.11 n/ac routers and access points use OFDM transmission techniques. They also supports MIMO transmission, which uses multiple input and multiple output antennas to improve signal transmission in indoor environments. MIMO also provides beamforming capabilities. Evidence: "Traditionally, radio engineers treated natural multipath propagation as an impairment to be mitigated. **MIMO** is the first radio technology that treats **multipath propagation** as a phenomenon to be exploited. MIMO multiplies the capacity of a radio link by transmitting multiple signals over multiple, co-located antennas. This is accomplished without the need for additional power or bandwidth. **Space–time codes are employed to ensure that the signals transmitted over the different antennas are orthogonal to each other, making it easier for the receiver to distinguish one from another.** Even when there is line of sight access between two stations, dual antenna polarization may be used to ensure that there is more than one robust path. **OFDM** enables reliable broadband communications by **distributing user data across a number of closely spaced, narrowband subchannels**.[1] This arrangement makes it possible to eliminate the biggest obstacle to reliable broadband communications, intersymbol interference (ISI). ISI occurs when the overlap between consecutive symbols is large compared to the symbols' duration. Normally, high data rates require shorter duration symbols, increasing the risk of ISI. By dividing a high-rate data stream into numerous low-rate data streams, **OFDM enables longer duration symbols**. A cyclic prefix (CP) may be inserted to create a (time) guard interval that prevents ISI entirely. If the guard interval is longer than the delay spread—the difference in delays experienced by symbols transmitted over the channel—then there will be no overlap between adjacent symbols and consequently no intersymbol interference. Though the CP slightly reduces spectral capacity by consuming a small percentage of the available bandwidth, the elimination of ISI makes it an exceedingly worthwhile tradeoff. "{6}
and operative for wirelessly and unidirectionally broadcasting the signal	The definition of broadcasting data packets is well known to those skilled in the art of data communications.	Commentary regarding broadcasting: IEEE 802.11n/ac supports broadcast transmission of data frames, in which case there the receiving end unit does not send an acknowledgement when it receives a data frame. In IEEE 802.11n (2009) the nomenclature for broadcast and multicast frames changed to "group addressed" frames. Generally, group addressed frames are

US9344183 – CLAIM 7	***Claim Element Interpretation & Support [patent column: lines]***	***Commentary & Evidence*** **{References at end}**
using OFDM modulation inside the indoor, multi-room, building environment	This patent claims priority from counterpart patent US7827581, which incorporated into this patent (US9344183) by reference. US7827581 includes a definition of broadcasting data packets. This explicit definition is consistent with the accepted meaning of the term. According to this definition, broadcasting digital data packets to transmit digital data packets in one direction (unidirectionally), with no hand-shaking mechanism for each digital data packet. In the example of a residential property, the services are distributed throughout a house. A single multimedia device (wireless multimedia center) distributes the services shown in Fig. 5 to end units located in the various rooms of the home. [3:36-40]	frames that are addressed to more than one destination. The Quality of Service (QoS) control field of a data frame is a 16-bit field that identifies the traffic category or traffic stream to which the frame belongs and other QoS-related information about the frame. The Ack Policy subfield (bits 5 and 6) of the QoS control field is used to specify whether or not the data frame requires an acknowledgement. The combination of bit 5 = 1 and bit 6 = 0 is used for group addressed data frames to indicate that an acknowledgement is not required for the data frame. Live streaming, such as sport events etc., frequently use Real Time Streaming Protocol (which runs over Real-time Transport Protocol, which in turn runs over UDP – User Datagram Protocol) because time delays can not be tolerated. Hence UDP is used because it does not perform retransmissions to correct data transmission errors nor does it perform handshaking between the transmitting station and receiving station. {12} {13} {14} Therefore, such transmission are broadcast transmissions as defined by the patent specification (note that US7827581, which specifically defines broadcasting as transmissions that do not perform handshaking is incorporated by reference into US9344183) and are spatially unidirectional by virtue of beamforming as described in the next section of this chart. <u>Evidence regarding broadcasting:</u> "**Frames transmitted to a broadcast** or multicast destination (Address 1 has the group bit set) have a duration of 0. Such frames are not part of an atomic exchange and **are not acknowledged by receivers**, so contention-based access to the medium can begin after the conclusion of a broadcast or multicast data frame." {2}  **Figure 7-1—MAC frame format** {8} **7.1.3.5 QoS Control field** "The QoS Control field is a 16-bit field that identifies the **traffic category** (TC) or **traffic stream** (TS) to which the frame belongs and various other **QoS-related information** about the frame that varies by frame type and subtype." {8}

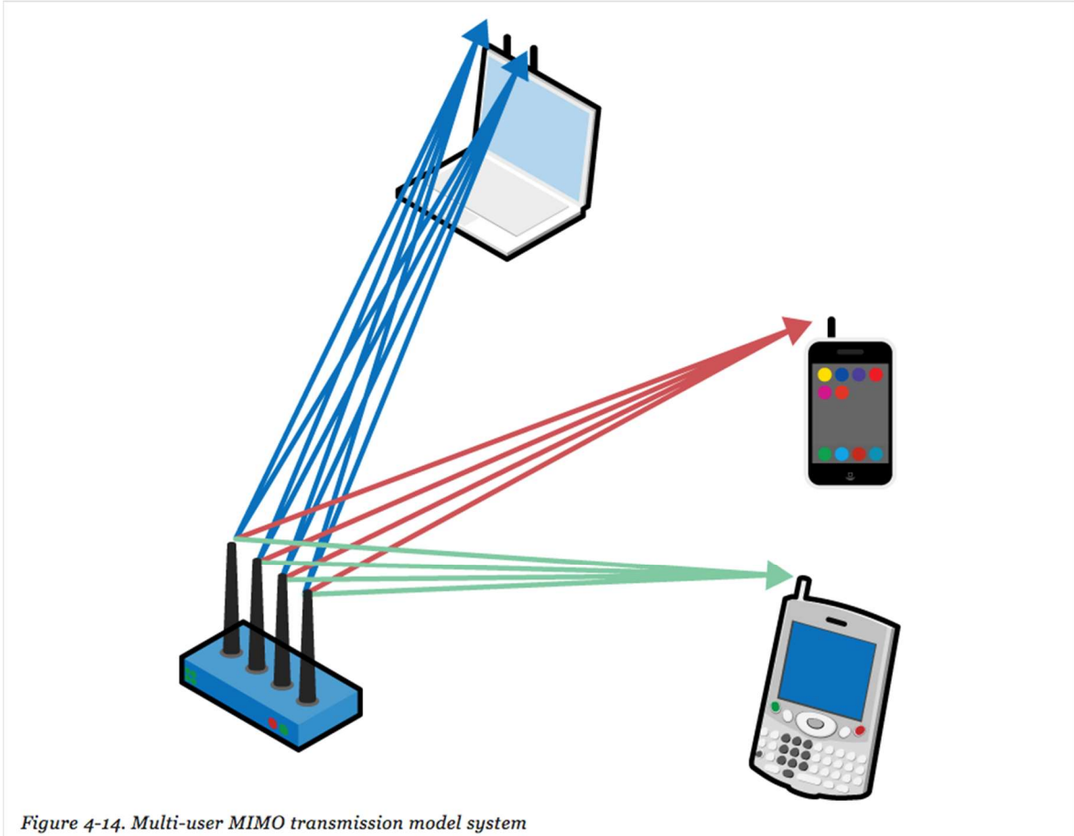
<table>
<tr><th>US9344183 – CLAIM 7</th><th>Claim Element Interpretation & Support [patent column: lines]</th><th>Commentary & Evidence {References at end}</th></tr>
<tr><td></td><td></td><td>
7.1.3.5.3 Ack Policy subfield

Table 7-6—Ack Policy subfield in QoS Control field of QoS data frames

<table>
<tr><th colspan="2">Bits in QoS Control field</th><th rowspan="2">Meaning</th></tr>
<tr><th>Bit 5</th><th>Bit 6</th></tr>
<tr><td>1</td><td>0</td><td>No Ack
The addressed recipient takes no action upon receipt of the frame. More details are provided in 9.11.
The Ack Policy subfield is set to this value in all directed frames in which the sender does not require acknowledgment. This combination is also used for ~~broadcast and multicast~~ group-addressed frames that use the QoS frame format. This combination is not used for QoS data frames with a TID for which a Block Ack agreement exists.</td></tr>
</table>
{8}
</td></tr>
<tr><td>from the distribution box in the one room in multiple directions</td><td>The limitation regarding “in multiple directions to a plurality of end units”, is taken to mean that the broadcast transmission is directionally specific as opposed to being omnidirectional. The transmission is made in the direction of the end units. Furthermore, the wireless multimedia center is capable of directing a transmission to a specific end unit. An end unit informs the WMC of the signal segment that the end unit is to receive. The</td><td>Commentary

In 2009, IEEE 802.11n introduced MIMO transmission capability, which supports directed beamforming. Beamforming enables transmissions to be spatially directed to a one or more diversely located receivers. In 2013, IEEE 802.11ac extended the maximum number of space-time streams supported from four streams in 802.11n to eight in 802.11ac. The Very High Throughput (VHT) physical specification (PHY) of 802.11ac applies to individually addressed and group addressed transmission (see the earlier discussion regarding broadcast/multicast transmissions now referred to as group addressed transmissions). The VHT PHY also provides support for downlink multi-user (MU) transmissions. A downlink MU transmission supports up to four users with up to four space-time streams per user with the total number of space-time streams not exceeding eight. The following figure depicts directed space-time streams being transmitted to end units. Note that either the transmission depicted by the blue arrows (i.e. eight streams) or the transmission depicted by the green arrows and the red</td></tr>
</table>

US9344183 – CLAIM 7	***Claim Element Interpretation & Support [patent column: lines]***	***Commentary & Evidence*** **{References at end}**
	WMC then directs a transmission of that signal segment, which is receivable by the end unit, to that end unit. [2:65-3:2]. One of the dimensions of the transmission is direction. [6:50]	arrows (i.e. total of eight streams) would occur simultaneously, so as not to exceed the maximum of eight streams. Evidence: **"22. Very High Throughput (VHT) PHY specification** **22.1 Introduction** **22.1.1 Introduction to the VHT PHY** Clause 22 specifies the PHY entity for a very high throughput (VHT) orthogonal frequency division multiplexing (**OFDM**) system. In addition to the requirements in Clause 22, a VHT STA shall be capable of transmitting and receiving PPDUs that are compliant with the mandatory PHY specifications defined in Clause 20. The VHT PHY is based on the HT PHY defined in Clause 20, which in turn is based on the OFDM PHY defined in Clause 18. The VHT PHY extends the maximum number of **space-time streams** supported to eight and provides support for downlink multi-user (MU) transmissions. A downlink MU transmission **supports up to four users with up to four space-time streams per user** with the total number of space-time streams not exceeding eight. NOTE—A VHT SU PPDU includes individually addressed and **group addressed transmissions**." {9}

US9344183 – CLAIM 7	*Claim Element Interpretation & Support [patent column: lines]*	*Commentary & Evidence* {References at end}
		 *Figure 4-14. Multi-user MIMO transmission model system* {7}
to the plurality of end units,	The signals received by the WMC are transmitted to the end units. There are a	Commentary:

<table>
<tr><th>US9344183 – CLAIM 7</th><th>Claim Element Interpretation & Support [patent column: lines]</th><th>Commentary & Evidence {References at end}</th></tr>
<tr><td></td><td>wide variety of end units that may receive signals from the WMC. The end units include video end units (VEU), e.g. for TV and radio, and communication end units (CEU), e.g. for telephone and data. [1:38-45] A video end unit may be a set-top box or may be incorporated in a TV. [2:31-33] A communications end unit may be separate boxes with various ports such as: serial, parallel, USB, Ethernet, IEEE 1394 or telephone-and/or-fax-and/or-modem. Alternatively, communications end unit PC card may be inserted into a computer. [2:48-52] End units may be adapted to Internet communication terminals, laptop computers, or personal information managers. [2:53-55] An end unit can be universal, analog, digital or both, communications, or any combination. [2:40-41]</td><td>An IEEE 802.11n/ac compliant wireless router or access point is capable of communicating with many types of end units. Examples of the various types of end units, which are 802.11n/ac compliant Wi-Fi client devices is given in the table below. These Wi-Fi client devices include handheld devices, laptops, tablets, PCs, digital TVs and set-top boxes.

Evidence:

<table>
<tr><th>Scenario</th><th>Typical client form factor</th><th>PHY link rate</th><th>Aggregate capacity (speed)</th></tr>
<tr><td>One-antenna AP, one-antenna STA, 80 MHz</td><td>Handheld</td><td>433 Mbit/s</td><td>433 Mbit/s</td></tr>
<tr><td>Two-antenna AP, two-antenna STA, 80 MHz</td><td>Tablet, laptop</td><td>867 Mbit/s</td><td>867 Mbit/s</td></tr>
<tr><td>One-antenna AP, one-antenna STA, 160 MHz</td><td>Handheld</td><td>867 Mbit/s</td><td>867 Mbit/s</td></tr>
<tr><td>Three-antenna AP, three-antenna STA, 80 MHz</td><td>Laptop, PC</td><td>1.27 Gbit/s</td><td>1.27 Gbit/s</td></tr>
<tr><td>Two-antenna AP, two-antenna STA, 160 MHz</td><td>Tablet, laptop</td><td>1.69 Gbit/s</td><td>1.69 Gbit/s</td></tr>
<tr><td>Four-antenna AP, four one-antenna STAs, 160 MHz (MU-MIMO)</td><td>Handheld</td><td>867 Mbit/s to each STA</td><td>3.39 Gbit/s</td></tr>
<tr><td>Eight-antenna AP, 160 MHz (MU-MIMO)
. one four-antenna STA
. one two-antenna STA
. two one-antenna STAs</td><td>Digital TV, Set-top Box, Tablet, Laptop, PC, Handheld</td><td>. 3.39 Gbit/s to four-antenna STA
. 1.69 Gbit/s to two-antenna STA
. 867 Mbit/s to each one-antenna STA</td><td>6.77 Gbit/s</td></tr>
<tr><td>Eight-antenna AP, four 2-antenna STAs, 160 MHz (MU-MIMO)</td><td>Digital TV, tablet, laptop, PC</td><td>1.69 Gbit/s to each STA</td><td>6.77 Gbit/s</td></tr>
</table>
{1}</td></tr>
<tr><td>the at least one end unit receiving the unidirectionally broadcast signal through the wall via packets each having a width of sufficient duration to resist multi-path</td><td>In the example of a residential property, the services are distributed throughout a house. A single multimedia device (wireless multimedia center) distributes the services</td><td><u>Commentary:</u>

Transmissions from IEEE 802.11n/ac compliant routers and access points are capable of passes through walls of an indoor, multi-room building. The excerpt from the referenced research paper describes an office scenario in which an 802.11ac access point was tested. The access point is depicted as a blue square in the figure. Wireless devices at locations E, G, and H receive non-line of sight transmissions through at least one interior wall. IEEE</td></tr>
</table>

US9344183 – CLAIM 7	***Claim Element Interpretation & Support [patent column: lines]***	***Commentary & Evidence*** **{References at end}**
reflection and absorption phase induced losses.	shown in Fig. 5 to end units located in the various rooms of the home. [3:36-40] Signals input to the multimedia device (wireless multimedia center) are then re-broadcast using OFDM technology throughout the premises. These signals are transmitted to and received by individual transceivers, called end units (EU), located throughout the premises. [1:38-43] All of the signals are added together and summed as an orthogonal array having dimensions of time, frequency and amplitude, to transmit spread spectrum multiplexed signals, in which each pulse including said signals has sufficiently long individual pulse widths to defeat multi-path, reflection and absorption phase induced losses. [5:42-47]	802.11n routers and access points are thought to have better wall penetration capability than similar 802.11ac systems because they transmit at 2.4 GHz, as compared to 802.11ac systems, which transmit at 5 GHz. Although some 802.11ac routers and access point support dual frequencies – 2.4Ghz and 5 GHz. **Evidence:** “3. 802.11AC THROUGHPUT & JITTER PERFORMANCE CHARACTERIZATION 3.1 Office scenario We deploy an **indoor 802.11ac WLAN testbed** in our offices, covering an area of 40×15m2. The office testbed is depicted in Fig. 1 with **the blue square indicating the AP and the red circles the clients**. The **average RSSI** and other characteristics **of each client** evaluated in the office testbed are **described in Table 1**. “{10}

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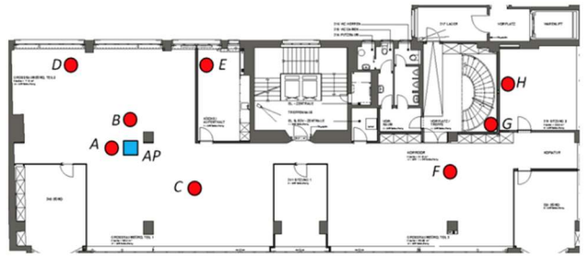

Figure 1: 802.11ac office testbed used for the throughput and latency measurements. The blue square indicates the access point and a red circle a client.

Link	RSSI	Line of Sight	Quality
A	-10 dBm	Yes	Strong
B	-14 dBm	Yes	Strong
C	-27 dBm	No	Strong
D	-40 dBm	No	Medium
E	-45 dBm	No	Medium
F	-57 dBm	No	Medium
G	-61 dBm	No	Weak
H	-75 dBm	No	Weak

Table 1: Average RSSI values for each link type in the office testbed, when using channel 149. {10}

"5Ghz does have a downside in that it is less able to penetrate solid walls and objects, so if you go outside your house to use your phone, your connection might drop. So to sum up, 2.4Ghz is very congested resulting in dropped connections and slow data throughput. However, it is better suited for transmitting data over longer ranges and through walls and other solid objects. 5Ghz by contrast, is what we'll call the "indoor" band. It's ideal for connections inside the house due to the lack of congestion, higher data transmission rates, and smaller

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		effective range. It's also the only band available if you want to take advantage of the newer, super-fast wireless AC standard. {11} **Commentary:** IEEE 802.11n/ac compliant routers and access points use OFDM transmission techniques that enable the transmission to resist multi-path reflection and absorption phase induced losses. The first references compares 802.11ac transmission testing (link quality) results between an office testbed, in which the interior walls were made of concrete and steel, to a home testbed, in which the interior walls were made of wood. In both cases the transmissions penetrated the interior walls, even though the walls made of concrete and steel provided a higher degree of reflections and multi-path effects. The second reference describes how OFDM signals resist these effects. Specifically, by distributing the data across multiple subchannels, the data rate on each subchannel is slow enough that the transmitted data symbols are of long enough duration to resist intersymbol interference, which is caused by the effects of multi-path reflection and absorption phase induced losses. Therefore, the transmitted packets, which comprise these symbols, are of sufficient duration to resist these effects. **Evidence:** "3.2 Home scenario To validate that the results presented in §3.1 are consistent in more than one testbed, we repeat the same characterization with the same methodology in a **home testbed** covering an area of 18 × 15m2 (mainly built of wood). The links evaluated are described in Table 4. Note that **we examined multiple different areas of the home environment but there was not high variation in link qualities** and therefore we only present four links. We see that the trend of the office regression (Fig. 3) heatmaps is similar is followed also in the case of the home testbed (Fig. 4). However, the trend for each feature in the home testbed is much clearer and more monotonic and consistent across the different link qualities because of the lack of high human interference, as well as the **material (wood) the home testbed is made of – compared to the office one (concrete, steel) – minimizing the impact of reflections and multipath**. "{10}

US9344183 – CLAIM 7	***Claim Element Interpretation & Support [patent column: lines]***	***Commentary & Evidence*** **{References at end}**
		"OFDM enables reliable broadband communications by **distributing user data across a number of closely spaced, narrowband subchannels**.[1] This arrangement **makes it possible to eliminate the biggest obstacle to reliable broadband communications, intersymbol interference (ISI)**. ISI occurs when the overlap between consecutive symbols is large compared to the symbols' duration. **Normally, high data rates require shorter duration symbols, increasing the risk of ISI. By dividing a high-rate data stream into numerous low-rate data streams, OFDM enables longer duration symbols**. A cyclic prefix (CP) may be inserted to create a (time) guard interval that prevents ISI entirely. If the guard interval is longer than the delay spread—the difference in delays experienced by symbols transmitted over the channel—then there will be no overlap between adjacent symbols and consequently no intersymbol interference. Though the CP slightly reduces spectral capacity by consuming a small percentage of the available bandwidth, the elimination of ISI makes it an exceedingly worthwhile tradeoff. "{6}

{1} New scenarios and configurations https://en.wikipedia.org/wiki/IEEE_802.11ac

{2} 802.11 Wireless Networks: The Definitive Guide, 2nd Edition, Chapter 4, 802.11 Framing in Detail https://www.safaribooksonline.com/library/view/80211-wireless-networks/0596100523/ch04.html

{3} Home networking: Everything you need to know https://www.cnet.com/how-to/home-networking-explained-part-1-heres-the-url-for-you/

{4} 802.11ac: what you need to know http://www.techradar.com/news/networking/wi-fi/802-11ac-what-you-need-to-know-1059194

{5} WiFi standards explained: what you should know about the new 802.11 ad, ah & af standards http://www.androidauthority.com/wifi-standards-explained-802-11b-g-n-ac-ad-ah-af-666245/

{6} MIMO-OFDM https://en.wikipedia.org/wiki/MIMO-OFDM

{7} 802.11ac A Survival Guide, Chapter 4: Beamforming in 802.11ac http://chimera.labs.oreilly.com/books/1234000001739/ch04.html

{8} IEEE Std 802.11n-2009

{9} IEEE Std 802.11ac-2013

{10} Evaluating 802.11ac Features in Indoor WLAN: An Empirical Study of Performance and Fairness **https://s3-us-west-1.amazonaws.com/disneyresearch/wp-content/uploads/20161017225518/Evaluating-802.11ac-Features-in-Indoor-WLAN-An-Empirical-Study-of-Performance-and-Fairness-Paper.pdf**

{11} What's the Difference Between 2.4 and 5-Ghz Wi-Fi? (and Which Should You Use) http://www.howtogeek.com/222249/whats-the-difference-between-2.4-ghz-and-5-ghz-wi-fi-and-which-should-you-use/

{12} Real-time Streaming Protocol: https://en.wikipedia.org/wiki/Real_Time_Streaming_Protocol

{13} Real-time Transport Protocol: https://en.wikipedia.org/wiki/Real-time_Transport_Protocol

{14} User Datagram Protocol: https://en.wikipedia.org/wiki/User_Datagram_Protocol

{15} Asus ProArt StudioBook 17 H700: https://www.asus.com/ca-en/Laptops/For-Creators/ProArt-StudioBook/ProArt-StudioBook-17-H700/

{16} Asus Search – Laptop Wifi: https://www.asus.com/ca-en/searchresult?searchType=products&searchKey=laptop%20wifi&page=1